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RESEARCH MEMORANDUM

AN INVESTIGATION OF THE HINGE-MOMENT FLUCTUATIONS OF 0.20-CHORD PLAIN AILERONS ON A HIGH-ASPECT-RATIO WING IN THE LANGLEY 8-FOOT HIGH-SPEED TUNNEL

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AN INVESTIGATION OF THE HINGE-MOMENT FLUCTUATIONS OF 0.20-CHORD PLAIN AILERONS ON A HIGH-ASPECT-RATIO WING IN THE LANGLEY 8-FOOT HIGH-SPEED TUNNEL

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SUMMARY

Concurrently with a three-dimensional lateral-control investigation made in the Langley 8-foot high-speed tunnel of a wing of high aspect ratio having 0.20-chord, straight-sided-profile plain ailerons, a few photographic records of aileron vibrations were obtained by means of an oscillograph connected to the electrical strain gage used to measure aileron hinge moments.

At supercritical Mach numbers, frequencies of the order of magnitude of 50 to 100 cycles per second were observed for the hinge-moment fluctuations of the aileron of the model. For a 104.5-foot-span airplane, full-scale hinge-moment-fluctuation frequencies (based on the model frequencies) are indicated to be of the same order of magnitude as the wing natural frequencies for an airplane of this size.

INTRODUCTION

One phase of a general research program undertaken by the National Advisory Committee for Aeronautics in connection with the design of a high-speed airplane with a high-aspect-ratio wing was the determination of the lateral-control characteristics of 0.20-chord ailerons on the wing. The results of these tests are presented in reference 1. Wake fluctuations behind the inboard station of the high-aspect-ratio wing were measured and these data are reported in reference 2.

During the aileron tests of reference 1 a few measurements were made of hinge-moment fluctuations; these measurements are recorded in the present paper. Fluctuation records were obtained at an angle of attack of 0° and an aileron deflection of -31.3°

for Mach numbers from 0.76 to approximately 0.925. A few fluctuation records were obtained for an aileron deflection of 5.5° at an angle of attack of 0°.

SYMBOLS

The symbols used herein are defined as follows:

α angle of attack of finite-span wing

V velocity in undisturbed stream

ρ mass density in undisturbed stream

a speed of sound in undisturbed stream

q dynamic pressure in undisturbed stream $\left(\frac{1}{2}\rho V^2\right)$

M Mach number (V/a)

δ_a aileron deflection; positive for down deflection

b_a span of aileron; model value, 0.590 feet

c_a section aileron chord measured along airfoil chord line from hinge axis of aileron to trailing edge of airfoil

$\bar{c}_a$ root-mean-square chord of aileron; model value, 0.0534 feet

$$\left(\bar{c}_a = \sqrt{\frac{1}{b_a}\int_0^{b_a} c_a{}^2\, dy}\right)$$

H_a aileron model hinge moment

C_{h_a} aileron hinge-moment coefficient $\left(\frac{H_a}{q b_a \bar{c}_a{}^2}\right)$

APPARATUS AND TESTS

The tests were made in the Langley 8-foot high-speed tunnel, which is a single-return closed-throat tunnel with an air-stream turbulence that is small but slightly higher than free air. For these tests the airspeed was continuously controllable to a choking

Mach number of 0.950 (uncorrected). The data presented herein are for corrected Mach numbers from 0.760 to 0.907 and for an uncorrected Mach number of 0.925. The Mach number corrections used may be found in reference 3.

Dimensions of the model wing and information concerning the test setup are to be found in reference 3. The wing has an NACA 65-210 section, an aspect ratio of 9.0, a taper ratio of 2.5:1.0, and no sweepback, twist, or dihedral. The aileron is of the plain type with no aerodynamic balance and has an unsealed gap that averaged approximately 0.003 wing chord. The aileron chord is 20 percent of the wing chord and the aileron span is 37.5 percent of the wing semispan, with the inboard end of the aileron at the 60-percent-semispan station. Two flexural hinges located approximately 25 percent of the aileron span from either end of the aileron supported the aileron. (See fig. 1.) The aileron has a straight-sided profile with a trailing-edge angle of 11.1°.

Hinge-moment data were obtained by use of an electrical strain gage, and frequency records were made by attaching an oscillograph to the strain-gage circuit and then making a photographic record of the hinge-moment fluctuations. The timer marks on the film were at 0.1-second intervals. A consideration of the interpretation and limitations of such frequency records is made in reference 2.

The mass-balanced aileron system of the model had a natural frequency of 625 cycles per second and had a damping constant about 2 percent of the critical damping constant of the aileron system. These values were obtained from a record, at zero airspeed, of the hinge-moment fluctuations ensuing when the aileron trailing edge was displaced from the equilibrium position and was subsequently released and permitted to vibrate freely. Counterbalances were attached to the aileron (fig. 1) to mass balance statically the aileron about its hinge axis; however, complete static balance was not obtained. This fact was ascertained by deflecting the wing tip from the equilibrium position and then releasing it and permitting the wing to vibrate freely. When this procedure was followed, a record showing slight amplitude obtained on the oscillograph indicated that the aileron was not perfectly mass balanced. The balancing, however, is believed to be sufficiently close so that accelerations of the wing tip did not seriously contribute to the vibrations of the aileron. From the slight oscillations recorded for the freely vibrating wing, the natural frequency of the model wing in the primary bending mode was determined to be about 50 cycles per second.

RESULTS AND DISCUSSION

In figure 2 are shown measured frequencies of the hinge-moment fluctuations of the aileron of the model. Frequencies of the order of magnitude of 50 to 100 cycles per second were observed. It is quite probable that higher frequencies existed as indicated by the data of reference 2. Also shown in figure 2 is a comparison of the data of the present tests with the wake-frequency measurements of reference 2, which were made behind the wing inboard stations of the model. Low-frequency wake fluctuations of the order of magnitude of 50 to 300 cycles per second were measured in the tests of reference 2. High-frequency wake fluctuations of the order of magnitude of 1300 to 1600 cycles per second were also measured in the tests of reference 2.

It is suggested in reference 2 that the frequency of the wake fluctuations at a given Mach number may be expected to vary inversely as the scale of the wing. If the assumption is made that a similar type of variation would occur for the aileron hinge-moment fluctuations, the present tests indicate that for an airplane of 104.5-foot span (33.3 times the size of the model tested) full-scale low-frequency hinge-moment fluctuations of 1.5 to 3 cycles per second would occur. These low-frequency hinge-moment fluctuations appear to be of the same order of magnitude as the wing natural frequencies that can be expected for wings of this size as determined by Army Air Forces tests.

Shown in figure 3 is the equivalent static hinge-moment-coefficient variation for a single aileron resulting from aileron load changes. These data apply for an aileron with no aerodynamic balance. The change in static hinge-moment coefficient is based on the double amplitude of the measured hinge-moment fluctuations divided by the magnification factor

$$\frac{1}{\sqrt{\left[1-\left(\frac{\upsilon}{\omega_n}\right)^2\right]^2+\left(2\frac{r}{r_c}\frac{\upsilon}{\omega_n}\right)^2}}$$

(see reference 4) where, for the present tests, υ/ω_n is the ratio of measured forced frequency to natural frequency for the aileron system of the model and r/r_c is the ratio of damping constant to critical damping constant for the aileron system of the model. The data of figure 3 show that the abrupt rise in hinge-moment-coefficient variation occurs in the same speed range as the

changes in force characteristics of the wing alone (reference 3). Dynamic hinge-moment-coefficient variations for any particular aileron with no aerodynamic balance, similar to the aileron tested, can be determined from the static data of figure 3 if the natural frequency and damping characteristics of that aileron are known. The hinge-moment changes presented here are for a single aileron; for two ailerons as on an actual airplane, where one aileron may either oppose or aggravate the effects of the other aileron, the net hinge-moment changes due to both ailerons may be expected to be different from the results for a single aileron.

CONCLUSIONS

From an investigation of the hinge-moment fluctuations of 0.20-chord plain ailerons on a high-aspect-ratio wing in the Langley 8-foot high-speed tunnel, the following statements can be made:

1. At supercritical Mach numbers, frequencies of the order of magnitude of 50 to 100 cycles per second were observed for the hinge-moment fluctuations of the aileron of the model.

2. For a 104.5-foot-span airplane, full-scale hinge-moment-fluctuation frequencies (based on the model frequencies) are indicated to be of the same order of magnitude as the wing natural frequencies for an airplane of this size.

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REFERENCES

1. Luoma, Arvo A.: An Investigation of a High-Aspect-Ratio Wing Having 0.20-Chord Plain Ailerons in the Langley 8-Foot High-Speed Tunnel. NACA RM No. L6H28d, 1946.

2. Ferri, Antonio: Preliminary Investigation of Downwash Fluctuations of a High-Aspect-Ratio Wing in the Langley 8-Foot High-Speed Tunnel. NACA RM No. L6H28b, 1946.

3. Whitcomb, Richard T.: Investigation of the Characteristics of a High-Aspect-Ratio Wing in the Langley 8-Foot High-Speed Tunnel. NACA RM No. L6H28a, 1946.

4. Freberg, C. R., and Kemler, E. N.: Elements of Mechanical Vibration. John Wiley and Sons, Inc., 1943, p. 55.

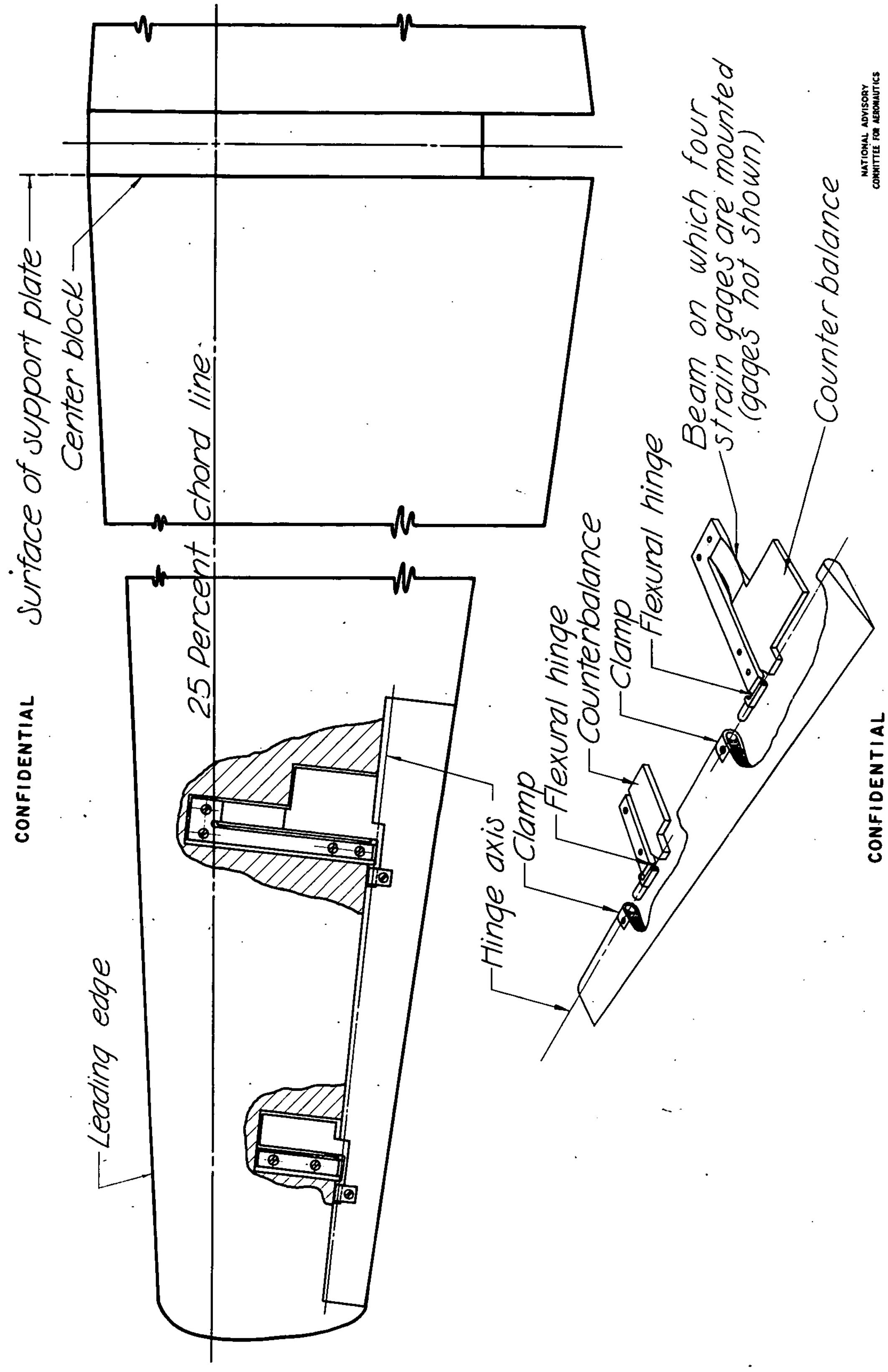

Figure 1.- Sketch showing hinges and counterbalance on left aileron on which hinge moments were measured.

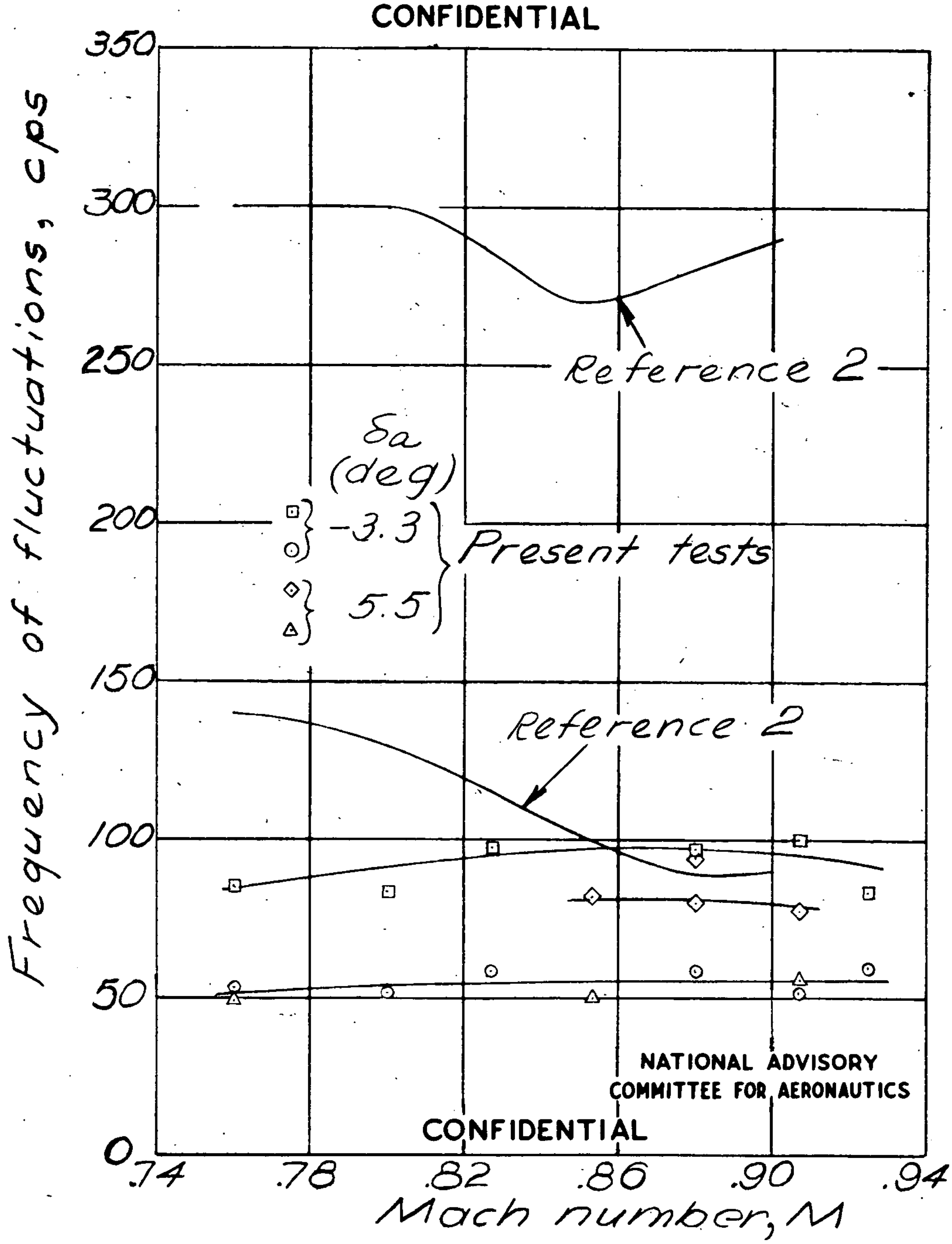

Figure 2.- Comparison of frequences of aileron hinge-moment fluctuations of model and wake fluctuations behind wing inboard stations of model. $\alpha = 0^{\circ}$.

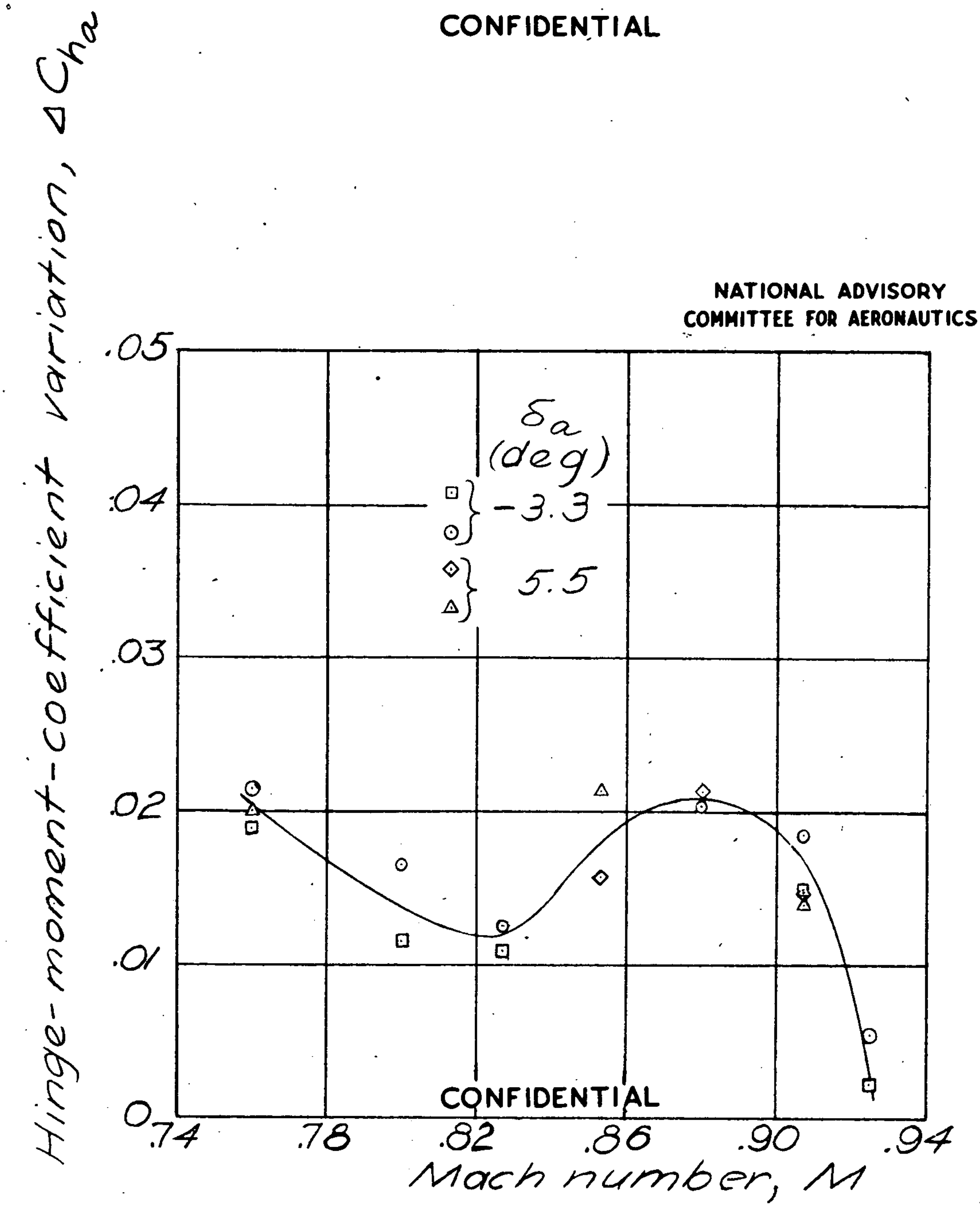

Figure 3.- Equivalent static hinge-moment-coefficient variation of single unbalanced aileron. $\alpha = 0^{\circ}$.